Project Title

Improving Mobility via Exoskeletons (IMOVE) – Implementing wearable robotic exoskeleton use across the continuum of rehabilitation care, from hospital to community

Project Lead and Members

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Project members:

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- Qiu Wenjing, Physiotherapist, Jurong Community Hospital
- Tang Ning, Research Fellow, National University Hospital
- Evania Wong, Research Coordinator, National University Hospital

Organisation(s) Involved

Alexandra Hospital (AH), Saint Luke's Hospital (SLH), Stroke Support Station (S3), NTUC Health, Saint Luke's Eldercare (SLEC), Jurong Community Hospital (JCH)

Healthcare Family Group(s) Involved in this Project

Medical, Allied Health, Healthcare Administration

Applicable Specialty or Discipline

Physiotherapy, Research

Project Period

Start date: Mar 2019

Completed date: Mar 2020

Aims

- To implement Robotic Exoskeleton Training (RET) across the continuum of rehab care (hospital to community)
- To study the effectiveness and manpower utilization in different settings

Background

See poster appended/ below

Methods

See poster appended/ below

Results

See poster appended/ below

Lessons Learnt

Adoption at rehabilitation settings which served inpatient and early post-discharge rehabilitation patients saw the best utilisation. Community facilities dedicated to specific population of patients who may benefit from RET would also be appropriate (eg. S3).

DRC physiotherapists were able to learn and apply RET appropriately. Therapists across all settings reported that RET was useful for rehabilitation.

The main barrier to adoption in the community was not seeing the patients who may benefit from RET. Centres run by 1 therapist were not suited to run RET, even if the device is shared. The need to block off all other activities at the centre during RET represented high opportunity cost for those running group therapy. Our partners accommodated for RET to be performed at larger DRCs when they found that it was not feasible at smaller centres. Still, demand was limited. Therapists need adequate practice to maintain their skills and adjust the training parameters according to patient needs.

Patients with FAC 0-1 are likely to have greater rehabilitation complexity and require an interdisciplinary team approach, beyond RET for mobility training alone. Transportation for outpatient rehabilitation remains a barrier to access. Hence, there is a need to locate centres in the community equipped with interdisciplinary teams able to address complex rehabilitation needs post-discharge, beyond the hospitals (including community hospitals). Not every DRC will be equipped, or will want to do this.

If we had to start over, 1 thing we would do differently would be to stipulate baseline requirements for centres who wish to undertake RET, including having adequate physiotherapy, occupational therapy and speech therapy support to manage the population of patients who would benefit from RET holistically. We would further pair these centres to inpatient rehabilitation facilities to form practice units where patients can be flowed to the community, with shared electronic medical records system. We would further stipulate that the rehabilitation physicians at participating hospitals, familiar with RET practice, should conduct multidisciplinary team meetings with the DRC to address rehabilitation issues and complications holistically and ensure goals are achieved.

These should be in place before RET programme implementation.

Conclusion

RET was trialed by 6 organisations across 8 sites and was successfully adopted by 4 organisations over 5 sites and will be incorporated into usual care at these sites. Further modifications to the workflow is needed for successful implementation with 2 organisations (elaborated in B9). As these organisations have the capacity to incorporate these changes, we believe that RET can be successfully implemented when these changes are in place.

Other rehabilitation facilities across Singapore have also adopted the technology (TTSH, HWA, St Hilda's).

Additional Information

2022 National HIP – Best Adoption Medal

Project Category

Technology

Digital Health, Tele-Rehabilitation

Care Continuum

Rehabilitative Care

Keywords

Robotic Exoskeleton Training, Stroke, Mobility, Functional Ambulatory Category

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Improving Mobility Via Exoskeletons (IMOVE) – Implementing wearable robotic exoskeleton use across the continuum of rehabilitation care, from hospital to community

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INTRODUCTION

Rehabilitation of mobility after acquired neurological injuries such as stroke is labour intensive. More than 80% of stroke survivors have impaired walking ability. 50% have long-term motor deficits (Duncan, 1992). Improved mobility is associated with decreased morbidity, mortality and complications across diseases.

Robotic exoskeleton training (RET) has been shown to be more effective than conventional physiotherapy (CP) to restore independent walking and improve walking speed for stroke and spinal cord injury. Those more acute and not independently walking benefit most (Merholz 2020, Merholz 2017).

Cost-effectiveness is unknown, especially in local context, and across different rehabilitation settings.

We undertook to implement RET across the continuum of rehab care (hospital to community) and studied the effectiveness and manpower utilization in different settings.

METHODS

Therapists in 6 organisations over 8 sites representing the continuum of rehabilitation care, were trained in RET.

Participating sites: the inpatient & outpatient rehabilitation facility of a tertiary rehabilitation unit (Alexandra Hospital), inpatient & day rehabilitation at community hospitals (Saint Luke's Hospital, Jurong Community Hospital); community day rehabilitation centres (Saint Luke's Eldercare, NTUCHealth Nursing Homes) & a community stroke survivorship rehabilitation centre (Stroke Support Station).

Design: A case-controlled study comparing outcomes of patients who underwent 12 sessions of RET vs those who underwent 12 sessions of CP at these sites.

Participants: Patients with Functional Ambulatory Category (FAC)* 0-3, deemed to benefit from mobility training with the wearable robotic exoskeleton, able to follow instructions. Those who chose not to undergo RET were recruited as controls.

Outcomes: 1) FAC, 2) Clinical Outcomes Variable Scale (COVS) 3) Functional Independence Measure (FIM) motor subscore (inpatients) 4) walking speed (those ambulant at recruitment) 5) number of person assistance required for manual-assisted walking, 6) number of steps taken and distance walked at therapy

**FAC 0=non-functional ambulator; 1=dependent ambulator, continuous manual assistance; 2=dependent ambulator, intermittent assistance or continuous light assistance; 3=supervision*

	AH	SLH	S3	NTUC	SLEC	JCH
FAC 0	95	34	5	6	0	2
FAC 1	36	21	11	1	2	8
FAC ≥2	41	24	20	0	0	5

Table 2: severity of impairment by FAC *(available data shown)*

RESULTS

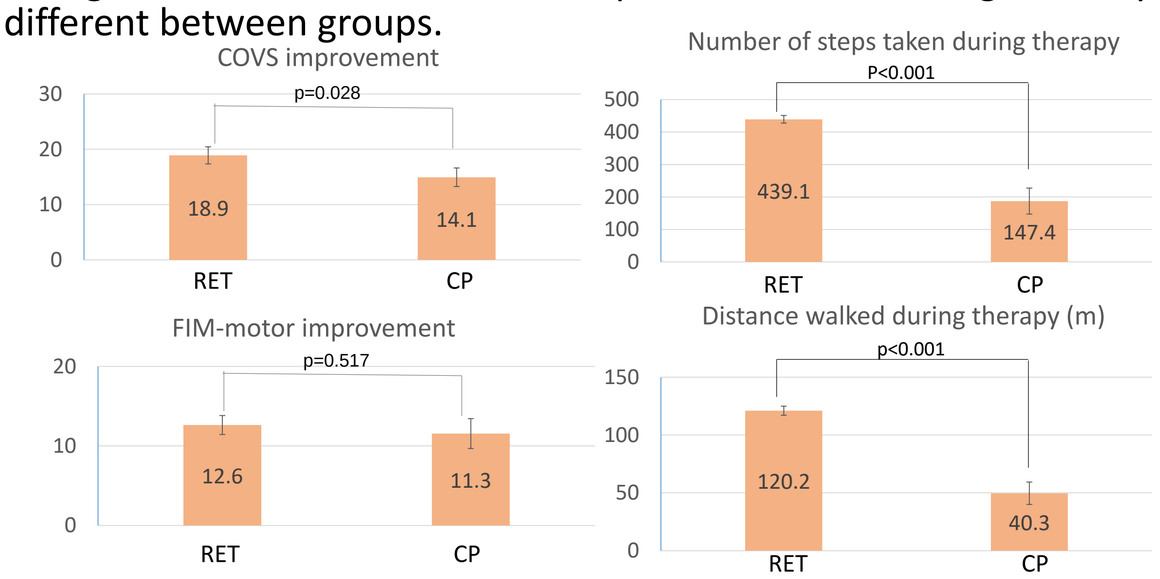
441 patients were recruited Mar 2019-Mar 2022 (350 intervention, 91 control) (Table 1,2).

Recruitment	AH	SLH	S3	NTUC	SLEC	JCH
Total	223 (9)	90 (0)	40 (2)	25 (0)	16 (0)	47 (4)
Intervention	175 (7)	83 (0)	31 (2)	17 (0)	11 (0)	33 (4)
Controls	48 (2)	7 (0)	9 (0)	8 (0)	5 (0)	14 (0)

Table 1: Distribution of recruitment. *Numbers in ( ) completed training Feb-Mar 2022 reflecting continued adoption*

Inpatients (baseline FAC 0-1):

Subgroup of 95 inpatients (63 RET, 32 controls) at AH were analysed as time to completion of 12 sessions was more consistent than outpatients. Number of steps taken and distance walked were 3 times more in the RET group vs control. Improvement in COVS was 34% greater with RET. FIM-motor improvement was not significantly different between groups.



Number of person assistance for manual-assisted walking was 1.9 (SE 0.1) for RET patients and 1.6 (SE 0.1) for controls (p=0.035).

All patients (baseline FAC ≥2)

Of 175 ambulant stroke patients across all settings, 139 underwent RET (35 acute, 48 subacute, 56 chronic); 36 were controls (13 acute, 13 subacute, 10 chronic). No significant diff in walking speed gains.

Walking speed (m/s, SE)	RET		p value	CP		p value
	Pre	Post		Pre	Post	
Acute	0.14 (0.04)	0.25 (0.06)	<0.001	0.17 (0.06)	0.58 (0.12)	0.035
Subacute	0.07 (0.02)	0.13 (0.03)	0.009	0.24 (0.09)	0.39 (0.12)	0.186
Chronic	0.23 (0.04)	0.27 (0.04)	0.007	0.25 (0.08)	0.31 (0.09)	0.043

Patient satisfaction survey

Of 182 patients, mean rating for ease of donning and doffing was 5.0/7, comfort was rated 5.5/7, on whether they felt safe when moving in the exoskeleton, rating was 6.0/7, on whether they felt their affected limbs were adequately supported, rating was 6.0/7, on whether they felt RET improved their walking ability, rating was 5.2/7. Overall rating of their experience with RET was 5.8/7. On likelihood of continuing to use the exoskeleton, rating was 5.6/7. On how much they were willing to pay above standard physiotherapy charges, mean was $29.41. Of the factors impacting decision to use RET, 74.2% cited cost, 30.5% cited time commitment, 26.3% cited usability.

Discussion

RET benefits more dependent ambulators. Training is more effective, greater improvement in function was seen with RET in this group. There was manpower savings as manual-assisted walking require 1.6-1.9 person assistance for this group whereas RET can be undertaken by 1 trained therapist ± untrained caregiver. Of patients admitted for rehabilitation to AH, 35-40% were FAC 0, 60% FAC 0-1. Indeed, most recruitment (81.6%) were from facilities with inpatient & outpatient rehabilitation. Recruitment in community DRCs was limited by lack of appropriate patients. Smaller DRCs found RET sessions came at high opportunity cost. Centres should have critical space, manpower and be resourced to address holistically complex rehabilitation needs of RET patients. Referral sources with team conferencing should be in place.